PUBLIC HEALTH REPORTS

VOL. XXVII. JUNE 28, 1912. No. 26.

NOTES ON MOSQUITO ERADICATION.

By GEORGE W. McCOY,[1] Passed Assistant Surgeon, Public Health and Marine-Hospital Service.

These notes are based upon the experience of a rather extensive antimosquito campaign undertaken in the city of Honolulu, Hawaii. The work was directed particularly against mosquitoes of the genus *Stegomyia*, or day mosquitoes, but in addition an effort was made to reduce as far as possible the number of night mosquitoes (*Culex*).

There seems to be no doubt that mosquitoes were unknown in the Hawaiian Islands prior to 1826, at which time they were introduced by a whaling vessel. There are but three species of the insects reported from the islands: *Stegomyia calopus*, *Stegomyia scutellaris*, and *Culex pipiens*.

Antimosquito work in Honolulu presented serious difficulties on account of certain local conditions. These were, first, the very large area covered by the city, 45,000 acres, in proportion to the population, 50,000; second, the fact that scattered tracts of land constituting about one-third of the area of the city were given over to the growing of rice and taro, both of which require the constant, or almost constant, flooding of the land; third, the enormous number of water-holding trees and plants.

The work used as the basis of these notes had to do only with the seeking out and abolishing of breeding places. The destruction of adult mosquitoes did not form a part of the work.

DISTRIBUTION OF DIFFERENT SPECIES OF MOSQUITOES.

Mosquitoes of the genus *Culex* were found breeding in all parts of the city, and, true to their habits elsewhere, in collections of water of every description. Swamps, puddles, house gutters, catch basins in the storm-sewer system, rice and taro fields, tin cans, bottles, holes in trees, water-holding plants, and toilet fixtures all furnished specimens of the *Culex* larvæ. Both species of *Stegomyia* were found in all sections of the city. The following tabulation of the breeding places of *Stegomyia* larvæ, collected early in the campaign, was pre-

[1] Detailed as sanitary adviser to the governor of Hawaii.

pared by Passed Asst. Surg. Edward R. Marshall, who made the identifications:

Location.	Stegomyia calopus.	Stegomyia scutellaris.	Location.	Stegomyia calopus.	Stegomyia scutellaris.
Storm sewer catch basin	1	2	Hole in tree	2	15
Watering trough	3	.....	Barrel	6	5
Street gutter	2	8	Bathtub	.....	1
House gutter	83	72	Cesspool	.....	2
Hole in rock	3	.....	Bucket	.....	2
Flower pot	1	1	Tin dipper	.....	1
Tin can	8	6	Crock	.....	1
Iron pot	1	.....	Keg hanging on tree	.....	1
Bottle	1	.....	Swamps	.....	1
Tin pan	1	.....	Puddle	.....	1
Water-holding plants	2	6	Hollow stump	.....	1
Tank	1	.....			

This table shows a disproportionately large number of house gutters furnishing larvæ, as at the time the identifications were made we were paying particular attention to these breeding places.

ANTILARVÆ AGENTS AND PROCEDURES EMPLOYED.

Coal oil.—Both crude and refined petroleum were employed. The crude oil available was that obtained from the oil fields of California. It was found to have a very limited field of usefulness on account of the lack of any tendency to spread over the surface of the water. Even when sprayed on a pool the oil was apt to remain in the form of drops. On many occasions living larvæ were found in collections of water that seemed to be satisfactorily covered by crude oil. Refined petroleum gave much better results, as it distributed itself quite well where the water was free from vegetation. In general oil was employed only on temporary collections of water and upon such permanent collections as it was found impracticable to deal with in any other manner.

Larvicide.—This agent was prepared in large quantities and used as a substitute for petroleum. The fluid was made by emulsifying crude carbolic acid with rosin and caustic soda. It was not observed that it presented any advantages over the refined petroleum except that perhaps it was a little more prompt in destroying larvæ and was a trifle cheaper.

Draining and filling.—Many acres of swampy land were drained, while others were filled. These are, of course, the ideal ways to abolish mosquito-breeding places, and should always be employed where circumstances permit.

Larvæ-destroying fish.—In 1905 Dr. David Starr Jordan, of Stanford University, Palo Alto, Cal., advised the stocking of the waters of Hawaii with larvæ-destroying fish. As a result of this advice the Territorial government brought about 400 of these fish (*Gambusia affinis*, *Fundulus grandis*, *Mollienesia latipinna*) from Texas. They have multiplied rapidly and are now found in almost all streams and ponds in the Territory. It is not too much to say that these little fish have proven more valuable than any other single agent in keeping the mosquitoes in the islands within bounds. It was astonishing how promptly they eradicated the larvæ from any collection of water

in which they were placed, provided they could gain access to all parts of it. In many cases it was necessary to clear the vegetation out of the pond or other large collection of water in order to permit the fish to get about freely. In other cases, where the water was shallow or in pockets, the flooding of the area so that the water was deep enough to permit the fish to reach every part proved sufficient to clear the place of larvæ. Oil or lavicide is fatal to fish and should not be placed in any collection of water that has fish in it or that is to be stocked with them. Fish have been used with great satisfaction in tanks, barrels, watering troughs, etc.

Flooding with salt water.—There were a few low places so situated that it was possible to lead sea water into them, converting a fresh-water pool into a brackish one in which the mosquitoes found in Hawaii do not breed.

METHOD OF TREATING DIFFERENT BREEDING PLACES.

Tin cans, bottles, etc.—As Honolulu does not have a system of free garbage collection, every vacant lot and many of the occupied ones were liberally sprinkled with tin cans, bottles, fruit jars, old kerosene cans, etc. These were buried or collected and hauled to a garbage dump. It is necessary to cover the dump with earth or to put the cans, etc., in salt water or one may merely transfer a nuisance from one place to another.

Pools and swamps.—These were treated by filling, draining, oiling, or the introduction of larvæ-destroying fish. When necessary the vegetation was removed to permit oil to spread or to allow the fish to reach every part. This was sometimes a task requiring much work.

There were a good many cases where swampy land could be converted from a breeding place into one quite free from mosquito larvæ by the process of extensive ditching. The earth that was taken out to make the ditches was piled in oblong mounds, changing a place that had previously been swamp into one where the earth and water were well defined and separate, thus permitting the fish to have access to every part where larvæ could exist.

As a large part of Honolulu is practically at sea level, many swamps and ponds that appear in every respect to be ideal breeding places contain no larvæ on account of the water being brackish. As it was important that efforts and funds should not be exhausted on work that was needless from an antimosquito point of view, it was made an invariable rule that, no matter how favorable a locality looked as a breeding place, no work was done on it if repeated inspections failed to show the presence of larvæ.

Irrigation of sugar cane.—The irrigation of sugar cane is carried on in such a way that the only place where mosquitoes breed in a cane field is in the ditches. The most feasible way of dealing with them where the grade is not sufficient to keep the water in motion is to stock the ditches with fish.

Taro patches.—Taro (*Colocasia antiquorum*), a tuber from which "poi," the principal food of the Hawaiians is made, grows under water. The depth of the water is from 2 to 6 inches, ample to permit fish to get about freely. The stocking of the patches with fish is the only practicable means of dealing with taro cultivation. The edges of the pond must be kept free from grass and weeds. Taro patches

that are in use give comparatively little trouble, but often those that are abandoned have water standing in pockets and are apt to be overgrown with alien vegetation. Filling or draining is the best treatment for these.

Rice fields.—Rice cultivation is one of the important industries of Honolulu. As it is ordinarily carried on it results in large crops of mosquitoes at certain periods. It is customary during the time that the field is being prepared for plowing and while the plowing is in progress to keep the land partially covered with water, which, of course, affords ideal mosquito-propagating conditions. The only solution we have found is to require the water to be kept deep enough to permit fish to gain access to every part. After the rice is planted ample water is kept on the land.

Pasture lands.—The many acres of pasture land in the city have given much trouble. The hoofprints of animals hold water and form excellent breeding places. Where draining is impracticable there is no way of dealing with these except by oiling or treating with larvicide. Even this is not satisfactory, as the little pools are easily overlooked and new ones are made hourly.

Banana plantations.—When banana shoots are started it is customary to have the little mound of earth in which the shoot is placed surrounded by a moat of water about 6 inches deep, 8 or 10 inches wide, and 3 or 4 feet in diameter. These moats form ideal breeding places. The only practicable way to treat them is to throw in enough earth to change the contents into mud.

Water-holding plants.—Among the plants that hold water bananas and several species of lilies may be mentioned. Whether mosquitoes breed often enough in the former to justify their destruction except at times of emergency is a much-disputed point. The writer believes that the removal of banana plants will always aid materially in mosquito eradication. Lilies and certain other plants that are common in Honolulu very often have a space between the stalk and the base of the leaf in which larvæ are found. In one case 25 out of 27 spider lilies on one premises had larvæ in them. The only way of dealing with water-holding plants permanently is to cut them down and grub out the roots. It was observed that when water-holding pockets in plants were filled with dust, dirt, leaves, etc., the water evaporated rapidly, and consequently there was no danger of mosquitoes breeding in them. In a few cases we have treated water-holding plants by putting sawdust in the pockets and have found that this served very well to facilitate the drying. This plan is not recommended, as it does not permanently abolish breeding places, but it may be used where people are unwilling to sacrifice the plants.

Sewer system.—Honolulu has " separate " sewer systems, and mosquito-breeding places have been found in each of the systems. The sanitary sewers have perforated iron manhole covers. Under these covers drip pans are suspended to catch street dirt that would otherwise fall into the sewer. For a time these drip pans were oiled, but it was finally concluded that probably they served no useful purpose, and the pans were removed.

The storm sewers had their chief source of trouble in the catch basins which receive the street drainage. These are practically brick and cement boxes, about 3 feet square and from 3 to 5 feet deep.

About a foot from the bottom is an outlet pipe communicating with the sewer main. As a result of this arrangement of the outlet pipe these catch basins generally hold about a foot of water, which forms one of the most important mosquito-breeding places. Several varieties of drip cans were tried for the purpose of keeping the water in the basin constantly covered with oil. It was found, however, to be more satisfactory and more economical to have the catch basins oiled by hand about once a week, 50 cubic centimeters of refined petroleum being placed in each basin. Partial blocking of the outlet pipe running from the catch basin to the main sewer frequently caused the water to stand in this pipe. The only way to deal with these collections was to have the catch basin emptied and the obstruction removed. This failing, oil could be applied to the water in the outlet pipe.

Other difficulties with the storm sewers were the sagging of sections or partial damming, either condition allowing water to stand. Cleaning and structural changes such as would be required to remedy these troubles did not come within our province. The keeping of these collections of water in the storm sewers oiled was not regarded as feasible.

Roof gutters.—The most difficult and at the same time one of the most important parts of the work of abolishing breeding places was in connection with house gutters that held water. These very frequently contained larvæ. Oiling and cleaning are but temporary measures. The remedy advised was to remove the gutters whenever practicable. Many of them sag, leak, or otherwise fail to fulfill the functions for which they were intended. A board of architects appointed under the authority of the Territorial board of health to investigate this subject recommended that gutters have a fall of at least 1 inch in 16 feet and that down spouts be provided along every 16 feet of the length of the gutter. My own observation has led me to believe that the fall should be greater than this.

Puncturing gutters was practiced to some extent. This is satisfactory only if holes not less than an inch in diameter are made along the whole water-containing part of the gutter. Holes made with large nails are useless, as they soon become clogged. Screening of gutters is not to be recommended as it is expensive and often fails to keep mosquitoes out. In a good many cases nothing could be done with gutters but to see that water was not allowed to stand in them.

Houses in the Tropics should be constructed with eaves that overhang enough to obviate the necessity for gutters.

Water barrels.—The rule was to oil any barrels in which larvæ were found. This usually induced the householder to keep them screened.

Cesspools.—Cesspools with defective covers form excellent breeding places. The remedy is a mosquito-proof cover (usually wood covered with earth) with a screened vent pipe. As a temporary measure oiling is sufficient. Overflowing cesspools cause a great deal of trouble. The remedy is to have the cesspool emptied.

Cavities in trees.—Holes in trees were frequently found to be breeding places. A very common tree in Honolulu, the kiawe or algaroba (*Prosopis juliflora*), is likely to have a cavity where large branches are given off, at forks, etc. To remedy these conditions the cavities

were filled with broken rock or earth and a covering of cement placed over the filling.

Throughout the work one thing that impressed us was the fact that the majority of collections of water on the ground were man made. For example: Many small swamps were due to an overflowing or leaky cesspool; pools in streets were often due to broken water pipes; a swampy yard was often caused by the waste water from a washhouse. Breeding places due to seepage from natural causes were rare.

TREATMENT OF VESSELS ARRIVING AT NEW YORK FROM WEST INDIAN AND SOUTH AMERICAN PORTS.

The health officer of the port of New York has issued the following special order to boarding officers at that port regarding the treatment of vessels coming from ports in the West Indies and South America:

SPECIAL ORDER TO BOARDING OFFICERS RELATIVE TO BUBONIC PLAGUE.

All passengers and members of crews on vessels entering this port from Porto Rican ports, Haitian ports, and ports in the West Indies and in South America to the southerly of Porto Rico, shall be individually examined with the utmost care for symptoms of bubonic plague.

All hides, including animal skins of every character, carried as cargo on such vessels shall be subjected to disinfection in accordance with general order No. 30, if practicable, on board the vessel at quarantine.

All holds of vessels entering this port from ports on the island of Porto Rico, the island of Trinidad and the port of La Guaira, Venezuela, shall be subjected to disinfection, after the discharge of all cargo therefrom, in this port by a representative of this department or under the direction and supervision of this department. For this purpose the provisions of general order No. 29 are hereby extended with respect to such vessels so as to provide for disinfection after every voyage. If the existence on board of perishable merchandise, liable to serious damage by the use of disinfectants, shall make the fumigation of hides at quarantine impracticable, the master of such vessel shall, before being admitted to pratique, sign a written agreement to submit such hides to fumigation at the dock, after the discharge of such parts of his cargo as may be liable to injury from the use of fumigants, and no vessel from ports on the island of Porto Rico, the island of Trinidad, and the port of La Guaira, Venezuela, shall be admitted to pratique until the master of such vessel shall have signed a written agreement to submit the hold of his vessel to fumigation after the discharge of his cargo, and to notify this department of the readiness of his vessel for such disinfection.

This order will remain in effect until the amelioration of plague conditions at the ports mentioned, and adjoining ports shall justify its modification.

JOSEPH J. O'CONNELL,
Health Officer, Port of New York.

June 20, 1912.